

# Implications of high-heeled shoes on body posture of adolescents

*Repercussões do uso do calçado de salto alto na postura corporal de adolescentes*

*Repercusiones del uso de zapatos con tacones en la postura corporal de adolescentes*

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## ABSTRACT

**Objective:** To review studies regarding effects of high-heeled shoes on body posture of adolescents.

**Data sources:** The research was conducted in the Scopus, SciELO and PubMed databases between 1980 and 2011, searching for articles written in English and Portuguese with the following key-words: “posture”, “center of gravity”, and “high-heeled shoes”. Among 55 retrieved articles, 20 were analyzed regarding posture of the spine and lower limbs, the center of gravity, and the effects of high-heeled shoes in the musculoskeletal system in adolescents.

**Data synthesis:** Frequent use of high-heeled shoes leads to modification of the gravity center and body balance, which can lead to changes in the alignment of body segments. This has a negative impact on motor development of adolescents. In this phase, it is necessary to keep the posture in order to maintain the physiological growth and development of the musculoskeletal system.

**Conclusions:** High-heeled shoes in adolescents can lead to the development of postural disorders, among which stands out the forward head posture, lumbar hyperlordosis, pelvic anteversion, and knee valgus. The height and width of the heels are characteristics that exert most influence in the emergence of postural changes and body imbalance.

**Key-words:** growth and development; adolescents; posture; biomechanics.

## RESUMO

**Objetivo:** Revisar estudos referentes às repercussões do uso de calçado com salto alto na postura corporal de adolescentes.

**Fontes de dados:** Pesquisa realizada nas bases de dados Scopus, SciELO e PubMed entre 1980 e 2011, incluindo artigos escritos em inglês e português. Foram utilizados os descritores: “postura”, “centro de gravidade” e “calçado de salto alto”. Foram encontrados 55 artigos, independentemente do desenho do estudo, incluindo-se 20 relacionados à postura da coluna vertebral e membros inferiores, à localização do centro de gravidade e às repercussões do uso do calçado de salto alto no sistema musculoesquelético em adolescentes.

**Síntese dos dados:** O uso frequente do calçado de salto alto acarreta modificação do centro de gravidade e do equilíbrio corporal, podendo ocasionar mudança no alinhamento dos segmentos corporais. Isso traz repercussões negativas ao desenvolvimento motor das adolescentes, pois nessa fase há a necessidade de manutenção da postura fisiológica para que ocorra o crescimento e o desenvolvimento do sistema musculoesquelético.

**Conclusões:** O uso do calçado de salto alto por adolescentes pode favorecer o aparecimento de distúrbios posturais, dentre os quais se destacam anteriorização da cabeça, hiperlordose lombar, anteversão pélvica e joelho em valgo. Identificou-se que a altura e a largura do salto são as características do calçado que mais influenciam no surgimento de alterações posturais e desequilíbrio corporal.

**Palavras-chave:** crescimento e desenvolvimento; adolescente; postura; biomecânica.

## RESUMEN

**Objetivo:** Revisar estudios referentes a las repercusiones del uso de zapatos con tacones en la postura corporal de adolescentes.

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Conflito de interesse: nada a declarar

Recebido em: 8/5/2012

Aprovado em: 14/9/2012

**Fuentes de datos:** Investigación realizada en las bases de datos Scopus, Scielo y Pubmed, entre 1980 y 2011, incluyendo artículos escritos en inglés y portugués. Se utilizaron los descriptores: «postura», «centro de gravedad», «zapatos con tacones». Se encontraron 55 artículos, independiente de la delimitación del estudio, incluyendo 20 artículos relacionados a la postura de la columna vertebral y miembros inferiores, a la localización del centro de gravedad y a las repercusiones del uso de zapatos con tacones en el sistema osteomuscular en adolescentes.

**Síntesis de los datos:** El uso frecuente de zapatos con tacones causa modificación del centro de gravedad y del equilibrio corporal, pudiendo ocasionar cambio en la alineación de los segmentos corporales. Eso trae repercusiones negativas en el desarrollo motor de las adolescentes, pues en esa etapa hay necesidad de mantenimiento de la postura fisiológica para que haya el crecimiento y desarrollo del sistema musculoesquelético, que cuando expuesto a la sobrecarga puede ocasionar desviaciones posturales con potencial para que se conviertan en irreversibles.

**Conclusiones:** El uso de zapatos con tacones por adolescentes puede favorecer el apareamiento de disturbios posturales, entre los que se destacan la anteriorización de la cabeza, hiperlordosis lumbar, anteversión pélvica y rodillas valgus. Se identificó que la altura y el ancho del tacón son las características del zapato que más influyen en el surgimiento de alteraciones posturales y en el desequilibrio corporal.

**Palabras clave:** crecimiento y desarrollo; adolescente; postura; biomecánica.

## Introduction

The use of high-heeled shoes is a habit increasingly common among adolescents, but it can trigger several changes in postural alignment, particularly in the lower limbs and spine<sup>(1)</sup>. Among these changes, we highlight forward head posture, lumbar hyperlordosis, pelvic anteversion, and valgus knee.

Standing in high-heeled shoes causes immediate and temporary postural changes because of the modification of the center of gravity (CG)<sup>(2)</sup>. By removing the heels, the body goes back to its original conformation. However, studies<sup>(3,4)</sup> have demonstrated the permanence of these postural changes with the excessive use of this type of shoes.

Postural imbalance can bring negative repercussions<sup>(2)</sup> when it affects adolescents, because, at this stage, there is intense growth and development of the musculoskeletal system, which, when exposed to overload, can cause irreversible postural deviations<sup>(5)</sup>.

Although studies relate the use of high-heeled shoes with postural changes in adult women, there is need for a better understanding of the influence of this type of shoes in the posture of adolescents, as little is known about its impact at that age.

Therefore, the present research aimed to review empirical studies regarding the impact of the use of high-heeled shoes on body posture of adolescents.

## Method

The present study conducted a review of the literature published in Portuguese and English in three scientific databases: Scopus, Scielo, and Pubmed. In the search for articles the descriptor “*postura/posture*” was used combined with “*centro de gravidade/center of gravity*”, and “*calçado de salto alto/high heel shoes*”.

The articles included were published between 1980 and 2011, regardless of study design, whose sample comprised, partly, or completely, females from 10–19 years.

The selected articles had to be related to the posture of the spine and lower limbs, the location of the center of gravity, and the effects of the use of high-heeled shoes on the musculoskeletal system in adolescents. Articles related exclusively to changes in gait resulting from the use of heels and changes in posture due to the use of handbags were excluded.

After searching the databases 55 articles were located, among which 20 met the inclusion criteria. Two monographs from 2009 and 2010, and three articles related to the use of high-heeled shoes, whose sample was composed of individuals of a different age group from the one determined as criterion for inclusion, were added in this review to provide substrate to the discussion.

## Literature review and comments

### Posture, center of gravity, and use high-heeled shoes

Posture is defined as the body position in space and the relative disposition of all parts of the body forming a global arrangement that establishes a direct relationship with the force of gravity<sup>(5,6)</sup>.

For biomechanics, the standing posture is the result of a dynamic state of balance between body and gravity, which is an external force that attracts the body to the ground. Thus, contraction of the posture muscles and continuous positioning of body segments occur during standing in order to maintain balance and to overcome the action of the gravitational force<sup>(3,6-8)</sup>.

Gravity acts in the body at a specific point, the CG, which is where all the mass of the body is concentrated. The CG of the human body does not have a fixed location, since, depending on the arrangement of the limbs, the head, and the trunk, there is variation in its positioning<sup>(6,9)</sup>.

In an orthostatic position, the CG is located, in general, over the second sacral vertebra, at the level of the hip<sup>(10)</sup>. Because of morphological characteristics, men and women have differences in the location of the CG. Compared to men, the center of gravity in women is slightly lower and up front, due to the wider pelvis and shorter legs<sup>(11)</sup>.

The body position in space may also contribute to changes in the CG. By adopting the standing position with heels, in which the elevation of the heels causes a superior and posterior shift of the CG, occurs the change of all postural alignment relative to a reference line, called a gravity line<sup>(2)</sup>. This line is originated in standing position when the force of gravity passes through the CG, and crosses the body in the frontal and sagittal planes. Depending on the relationship of this line with the body parts, it is possible to classify body posture as adequate or inadequate<sup>(8)</sup>.

In adequate posture, the line of gravity coincides with the midline of the body in the sagittal plane, so that the left and right halves of the body are symmetric and in balance. In side view, the line of gravity corresponds to the frontal plane that divides the body into anterior and posterior sections, starting slightly anterior to the lateral malleolus, crossing the lower limb and spine, and passing in the middle lobe of the ear to reach the top of the head<sup>(12)</sup>. Maintaining this posture requires minimal pressure on bones, muscles, and joints, with less energy spending and less risk of injuries. However, there may be temporary variations of this postural alignment and line of gravity without affecting the musculoskeletal system<sup>(13)</sup>.

An inadequate or poor posture occurs with the continuation of a defective relation of the various parts of the body with the line of gravity, which produces more pressure on support structures and a less efficient balance of the body over its support bases<sup>(5)</sup>.

The use of high-heeled shoes is a factor that can cause temporary or permanent bodily adjustments, depending on the time and frequency of use of this footwear and predisposes to poor posture especially in the spine and lower limbs<sup>(2-4,9)</sup>.

The manifestation of these postural changes associated with continued use of high-heeled shoes in adolescence may result in a loss in growth and delayed motor development, as this phase corresponds to the period of maturation of the musculoskeletal system<sup>(5)</sup>.

### **Immediate, temporary, and permanent postural repercussions from the use of high heels in adolescents**

Standing with high-heeled shoes generates postural adaptations due to the change of the position of the feet and of the location of the CG<sup>(2)</sup>. The heels provoke first the elevation of the calcaneus bone associated to the flexion of the tibiotalar joint<sup>(10)</sup>. Changing the alignment of the ankles causes elevation and forward displacement of the CG, causing postural imbalance, promoting adaptive postural adjustments for balance recovery and to maintain the upright posture<sup>(2,10)</sup>.

This is because when you are on shoes with high heels, musculoskeletal harmony is potentially unstructured, yet the power of adaptability of the postural system meets these demands until its compensation threshold. By exceeding this threshold, either by increasing heel height, length of time with the shoes, or decrease of the base of support, postural changes are evident<sup>(14)</sup>.

To minimize and restore the displacement of the CG there are temporary responses in appropriate muscle synergies, producing effective motor actions such as anterior tilt of the pelvis, posterior displacement of the trunk and increased lumbar lordosis which tend to rebalance the body in the standing posture<sup>(15)</sup>.

Thus, by removing the high heels, with the redistribution of plantar pressures and positioning of the ankles in neutral position, the body goes back to its original conformation. However, studies have reported the permanence of these changes associated with bone and muscle adaptations in users of shoes with high heels, even after the removal of the footwear<sup>(2,10,16)</sup>.

In general, there are many postural changes arising from the habit of wearing high heels in adolescents, as shown in Table 1. The foot is the first body segment that undergoes modifications due to the high heel. This kind of footwear favors the supination of the foot, reducing the width of the plantar arch<sup>(2)</sup>, increasing plantar pressure on the forefoot, and the higher the heel, the lower is the pressure on the hindfoot and the higher the pressure on the forefoot<sup>(15)</sup>.

The change of foot positioning associated with increased plantar flexion induced by high heels, causes increased recruitment of motor units in the muscles of the medial and lateral gastrocnemius as heel height increases<sup>(17)</sup>.

Since the use of high heels causes changes in the mechanics of the foot and ankle, considering that the muscle group adapts to the imposed conditions, it is expected that

**Table 1** - Impact of the use of high-heeled shoes in adolescents

Author	Sample	Method for postural assessment	Results of postural assessment
Bertocello <i>et al</i> <sup>(3)</sup>	30 adolescents aged between 18 and 22 years.	The Bank of Wells was used to assess flexibility of the posterior chain muscles, the Romberg test adapted for balance assessment, and physical examination for postural assessment.	Misalignment of the iliac crests, valgus knee, and pelvic anteversion. Regarding muscle contraction, the higher the heel height, the lower the flexibility of the posterior chain. There was a decreased balance in adolescent wearers of high-heeled shoes.
Iunes <i>et al</i> <sup>(17)</sup>	40 women. Users with a means age of 23.5±2.7 and nonusers with 22.6±2.7 years.	Posture analysis by computerized photogrammetry.	The head was leant forward in women who used the shoes more frequently. The stiletto changed the alignment of the knee in women unaccustomed to wear high heels. There was no relationship between the type of heel and the postural changes.
Lee <i>et al</i> <sup>(18)</sup>	200 women aged between 18 and 30 years.	Electromyography in the spine erector muscles and lumbar angle was measured by photogrammetry.	Decrease in the angle of lumbar flexion as the heel height increased and increased muscular activity of the spine erector muscles.
Pezzan <i>et al</i> <sup>(19)</sup>	20 adolescent users of high heels aged between 13 and 20 years.	Use of pedigraph, photogrammetry and photographic records.	Users presented hindfoot varus angle greater than the nonusers, both barefoot and wearing shoes.
Pezzan <sup>(20)</sup>	50 adolescents aged between 13 and 20 years.	Use of Computerized photogrammetry.	Nonusers presented straightening of lumbar lordosis and pelvic tilt, while the users showed lumbar hyperlordosis and pelvic anteversion. There was a correlation between increased lumbar lordosis and pelvic anteversion and the use of high-heeled shoes.

compensatory ascending postural changes be produced, and consequently, changes in the lower limbs and spine<sup>(18)</sup>.

In knees, the use of high heels increases the forces imposed on the femoropatellar articulation and in the medial compartment, thus valgus knees are observed with greater frequency among adolescents who wear high heels<sup>(3)</sup>, being more pronounced in those who wear needle heels<sup>(19)</sup>.

The change in knee alignment induces an internal rotation of the hips and, hence, a pelvic anteversion, which favors the onset of lumbar hyperlordosis<sup>(3)</sup>. Furthermore, as the use of high heels requires greater recruitment of the posterior chain muscle groups at the expense of the anterior<sup>(20,21)</sup>, there is a decrease in the flexibility of the spinal muscles and distention of the abdominal

muscles, which causes anterior displacement of the CG and favors lumbar hyperlordosis<sup>(3,22)</sup>.

However, there is no consensus in the literature regarding the posture of the lumbar spine caused by the use of heels. Some studies<sup>(10,23)</sup> indicate a pelvic tilt and lumbar adjustment, induced by the high heel, as consequences of vertical integration in the sacrum due to increased activity of the hamstring muscles to counteract the gravity line.

Regarding the cervical spine, a study shows increased lordosis due to the forward displacement of the head<sup>(18)</sup>.

The misalignment of the spine and lower limbs due to the use of heels may predispose to musculoskeletal disorders in adolescents, and low back pain is one of the main problems described in the literature in users of high heels. Its

development is not yet clear, however, the increased activity of the erector spine muscles and abdominal distension during the use of the heels may be associated with discomfort and fatigue reported by users<sup>(20)</sup>.

Aside from back pain, other disorders such as degenerative changes in the knee joint<sup>(4)</sup> and a tendency to the appearance of hallux valgus<sup>(21)</sup> may be associated with the use of the heels, having its onset in adolescence and aggravation in adulthood<sup>(21)</sup>.

To avoid occurrence of musculoskeletal symptoms and installation of permanent postural disorders in adolescents, it is critical to perform an early evaluation of body posture<sup>(8)</sup> by orthopedists and physiotherapists, to identify potential musculoskeletal adaptations and indicate appropriate corrective measures.

### Characteristics of high-heeled shoes and their relation with posture

There are several types and characteristics of footwear used by teenagers, varying in relation to height and width of the shoe heels and the inclination of the sole. A high-heeled shoe causes damage to the musculoskeletal system, when the height of the sole promotes an inclination, characterized by elevation of the heel region of support in relation to the forefoot<sup>(15)</sup>. Footwear that has a heel size that is equal or close to the height of the forefoot sole does not cause horizontal imbalance of the sole and, therefore, will not affect the biomechanical alignment of the ankles, functioning similarly to the shoes without heels<sup>(19)</sup>.

The heel height corresponds to the length from the tip of the heel that comes in contact with the ground until its deployment in footwear. By analyzing the shoe heel, two different measures should be considered: the real and the apparent height. The apparent height of the shoe corresponds to the size of the heel from the point of its insertion into the sole, while the actual height is the length of the heel minus the height of the anterior sole of the shoe. The actual height will determine the angle of inclination of the sole and heel height in relation to the forefoot<sup>(19)</sup>.

Another feature of the shoe that is poorly explored in the literature is the width of the heel, which can be thick, medium, or thin. The thick heel allows the force applied by the heel on the shoe sole to cross the heel evenly and be distributed over a wide area on the ground, ensuring the balance of the user<sup>(4)</sup>. The most common thick heels are: platform wedge and wedge shoes.

The platform wedge shoes are very stable<sup>(21)</sup>, and as they have a thick and wide sole throughout their length, they

support and distribute pressure throughout the entire foot, ensuring the balance. However, due to the width, the sole is not flexible, reducing the mobility of the foot. Wedge heels are slightly narrower in the rear foot region than and as wide as the support base of the heel, allowing good stability and causing an inclination of the tibiotarsal joint, since the sole of the forefoot region is thinner than that of the hindfoot region<sup>(13)</sup>.

The stiletto shoes present a very reduced area of pressure distribution on the ground, which can hinder the alignment of the ankle, leading to an imbalance and increased risk of sprains as it increases the size of the heels<sup>(21)</sup>. The medium heels have greater stability, since plantar pressures can be distributed on a larger area, but which is smaller than the base of the heel support. Generally, they have a square or reel shape, and are known as Louis XV heels<sup>(17)</sup>.

The type of shoe heel can also affect balance and posture. Numerous types of heel shoes can be classified as sandals, shoes, and boots, among others. The open sandal is the one in which the sole is attached to the feet by straps and can present the three types of heel cited previously<sup>(17)</sup>. There is a variation of sandals called pep toe sandals, which are characterized by a small platform in the forefoot region, and a thin and long heel. This characteristic, of a thicker heel at the anterior region of the foot, allows reducing the influence of the inclination angle of the ankle<sup>(13)</sup>. Some shoes hold only the forefoot region, being opened at the region of the ankle. By not going around the feet, they are considered unstable, promoting insecurity during gait, like the high-heeled shoes<sup>(15)</sup>.

Shoes are traditionally closed and hide the entire region of the heel and the toes. The tip of the shoes can have a square, round or cone-like shape, and can be classified as thin or wide. The pointed-tip shoes are those in which the region involving the phalanges narrows from the region of the metacarpophalangeal joint until the tip of the distal phalanges. They have a very reduced space for the toes, so that there is overlapping of fingers, which can induce problems such as hallux valgus<sup>(20)</sup>. The *Scarpin* has a narrow tip and middle and high heels. The shoes with wide tips ensure adequate space for the metatarsals and phalanges and generally have an oval or square shape.

There are several types of shoes in relation to the region of the ankle. The mules are closed at the front and opened at the ankle region while the Channel is closed at the front and has a strip on the ankle area<sup>(24)</sup>. The lack of adequate support in the region of the calcaneus in these types of footwear increases instability and favors plantar flexion caused by the

**Table 2** - Effects on posture, according to duration, frequency of use, type of use, and height of heels

Author	Type of shoes or heels	Heel Height	Time of use	Frequency of use	Repercussions in posture
Bertoncellos <i>et al</i> <sup>(3)</sup>	Not defined	8cm	Minimum 2 years	Daily	Decreased balance
lunes <i>et al</i> <sup>(17)</sup>	Needle and Wedge Platform	6.5 and 8cm	Not defined	Daily	Forward displacement of the head in users of the 2 types of heels and changes in knees in users of needle heels
Lee <i>et al</i> <sup>(18)</sup>	Not defined	Medium – 4.5cm High – 8cm	Not defined	Not defined	Increase of lumbar lordosis in two sizes of heels
Pezzan <i>et al</i> <sup>(19)</sup>	Wedge Shoes	10cm	Minimum of 1 year	4 times a week for 4 consecutive hours	Increase of lumbar lordosis and pelvic anteversion

high heel, lateral deviation of the calcaneus, and stretching of the ligaments of the lateral compartment of the ankle.

The boots<sup>(17)</sup> may also present heels and tips of different shapes, however, a special feature of this kind of footwear is the presence of the upper, which can be: long, when they are knee-high, or even up to the thigh; or short, when it extends slightly above the ankle. An advantage of the upper is the increase of stability of the ankle region, which is completely covered by the shoe<sup>(17)</sup>.

The tennis shoes are mostly sports models, however, there are now models with high heels, i.e., a tennis with ankle rise<sup>(24)</sup> which can cause the same damage of a traditional high-heel shoe. The advantage is that tennis offers greater stability to the ankle joint, being regarded as the best type of footwear to inhibit pronation of the foot<sup>(25)</sup>.

However, depending on the type and characteristics of the high-heeled shoes there can be a sum of factors that may contribute to the biomechanical imbalance of the ankle and predispose to compensatory postural dysfunctions<sup>(15)</sup>.

Table 2 shows the studies that assessed the effects on body posture in relation to the characteristics of footwear. Among the major changes, stand out the forward displacement of the head<sup>(21)</sup> and the lumbar hyperlordosis<sup>(16,15)</sup> that were related to the use of heels between 4.5 and 10cm tall.

In addition, Table 2 shows the effects of the height and width of the heel on the plantar pressure and on balance. It is observed that the higher the heel height, the more pronounced the misalignment of the ankle in plantar flexion and the greater plantar pressure in the forefoot area, promoting overload in this region<sup>(26)</sup>. It was also found that, the thinner

the shoe heels, the greater the instability of the ankle, the greater the overall imbalance<sup>(3)</sup> and the greater the postural impairment<sup>(20)</sup>.

Several authors<sup>(3,16,27)</sup> indicated that the size of the heels is related to the intensity of the motor effects. However, few mentioned the method used for measuring the length of the heels. Some studies<sup>(15,21)</sup> categorized the size of the heels as low, medium, or high without reference of the measurement considered. Another difficulty in assessing heel height was that there is no consensus in the literature regarding the size of the heels, frequency of use, and minimum time of use that can lead to postural changes and musculoskeletal disorders.

Thus, further research should be conducted, because knowledge of the effect of the use of high-heeled shoes in the posture of teenagers becomes imperative for professionals in order to identify early disturbances caused by this habit and to help in the prevention and guidance on the most appropriate treatment. Furthermore, it allows the guidance of parents or guardians in changing behavior and making the correct and safest choice in relation to the type of footwear suitable for this population.

## Conclusion

The present review showed that the use of high heels by adolescents may favor the onset of postural disorders, especially forward head, lumbar hyperlordosis, pelvic anteversion, and knee valgus. Furthermore, it was observed that the height and width of the heels are the characteristics that most influenced postural and body imbalance.

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